Controlled-Source Study of the Las Vegas Basin: Assessing Seismic Hazards in Southern Nevada

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Introduction

The Las Vegas Valley is located in the southern Basin and Range, which has undergone a significant amount of extension that continues today. This extension has resulted in a series of normal faults as well as strike-slip faults that cut across the region. In the Las Vegas Valley, these faults have contributed greatly to the original geometry of the basin. The cities of Las Vegas, North Las Vegas, and Henderson sit atop this fault-bounded basin, which has been shown to have varying amplification factors (e.g., Su et al., 1998). Recent paleoseismic studies have illuminated that several normal faults in the Las Vegas region have Quaternary offsets and have the potential to produce an earthquake of M6.5 to 7.0 (Slemmons et al., 2001). A gravity inversion, which combined gravity, seismic reflection, and aeromagnetic data indicate that there are a series of sub-basins exist beneath the unconsolidated basin fill, with the deepest sub-basin occurring 5 km west of the fault block bounding the eastern edge of the basin and the basin depth ranging from 2 km in the west-northwest to 5 km in the east-northeast (Langenheim et al., 2001). As a result, new studies have taken place to characterize the Las Vegas Valley for seismic hazards. The primary questions we have set out to answer are: 1).What is the geometry and velocity structure of the Las Vegas basin? 2). Can we identify existing faults and address their significance for seismic risk? 3). Can we identify of any sub-basins within the larger basin, thereby testing the model produced from the gravity inversion?

Experiment

The first year of this project involved acquiring new seismic refraction data across the Las Vegas Valley. With additional funds secured from Lawrence Livermore National Laboratory (LLNL) and the Applied Research Program at UNLV we were able to add two more profiles a few more shots than was previously proposed in the original U. S. Geological Survey NEHRP Grant. We spent the first 6 months of the project locating shot points and acquiring permits for those locations. Starting May 2003, a team of undergrads and graduate students started surveying the 825 stations locations across the Las Vegas basin at 100 m station spacing. This took about 8 weeks to complete the surveying using a Trimble GPS system. The two weeks prior to the initiation of the experiment involved the purchasing of supplies for the 20 crews that would be sent out to deploy the instruments. Drilling and loading of the explosives took place the week prior to the initiation of the seismic experiment. In August 2003, UNLV with the assistance of the University of Texas at El Paso, Stanford University, University of Nevada Reno and St. John's University acquired seismic refraction data and broadband data across the Las Vegas basin. The SILVVER '03 (Seismic Investigations of the Las Vegas Valley: Evaluating Risk) project was designed to acquire 3-D seismic data across the basin (Figure 1). The experiment consisted of three seismic refraction profiles, two at 55 km in length and one 7 km in length. One profile extended from the northeast, across the Las Vegas Valley Shear Zone and the transition from the deep to shallow portions of the basin to the southwest. The second profile extended from the southeast from Frenchman Mountain to the northwest towards the Nevada Test Site along a corridor that is thought to focus energy into the Las Vegas Valley. The third profile trended east-west in between the other two profiles together. Station spacing along the profiles was nominally 100 to 200 m using both vertical component "Texans" and 3-component RT130's. The RT130's were set for continuous recording while they were deployed. Shot point spacing was on the order of 10 km and 8 shots that were successfully recorded ranging in size from 50 to 1000 lb. The broadband stations were installed with the help of LLNL and were an unexpected addition to our original project.

There were several problems that occurred during the first of the project. One such problem was the amount of paperwork that was required to permit the shot points from the BLM. We ended up having to hire a consultant to handle the acquisition of these permits, which took until a week and half before the initiation of the experiment. Another problem we faced was that the drilling I had contracted with quit a week before we were to start drilling. Unfortunately the bid I had received from this company was very low and getting another drilling company for that same price was problematic. In the end a local drilling company worked with us to get the holes drilled. The press was very attracted to this project and the story broke a week earlier than anticipated, which lead to a tremendous amount of distraction while trying to get the project ready to go. Although this was a huge distraction, the press did a fairly good job in presenting the issues and the community was very supportive of our endeavor including the shooting. There were a couple of problems that could not be resolved. We had three shot points fall through due to permission issues, two of these at the last minute. Another problem we faced that could not be fixed was that one of our shots was shot 1 minute early, this was due to a communication error and we lost that data as a result. Finally the graduate student who was slated to work on this project for his thesis quit the project last May. As a result, I have hired an undergraduate and another graduate student to help with the processing of these data.

Future Work

In the end 792 instrument were placed on the ground for a 3 day period (Figure 1). One instrument was stolen and has not been recovered. The data has been downloaded and overall the quality is very high, especially since the majority of the instruments were deployed in the urban area. We are in the process of installing the geometry of these data and are planning on presenting initial results at the upcoming American Geophysical Union meeting. The raw data thus far looks very good. There are clear first arrivals across the profiles from the shots that were 1000 lbs (Figure 2). The data from this experiment will be used to produce a 3-D tomographic velocity model of the Las Vegas basin. In the second year, we will continue to produce the 3-D tomographic model and integrate the other geophysical and geologic studies that are currently being acquired. We believe that we will be able to tie in a general sense with geotechnical results by the production of a geologic cross section that fills in the gap between our model and the geotechnical model. The 3-D community model has been defined already and is awaiting the input of our results. In addition to the seismic refraction profiles, we set out 6 broadband stations across the Valley in an effort to record the chemical blasts. These instruments are currently deployed and recording continuously. Only the larger shots were captured by the broadband array. We will continue to service these stations for as long as we have this equipment. These data will be used to further our understanding of the Las Vegas basin and the potential seismic hazards that the region faces. In addition, these newly acquired datasets will be integrated into a 3-D community model that is being developed by the working group that will identify areas in the Valley where there could be an increase of amplification due to strong ground motion.

References

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Non-Technical Summary

The SILVVER seismic experiment was designed to image the Las Vegas basin in 3-D. The data recently acquired in August 2003, show that these goal should be met. We deployed 792 seismic recorders across the Las Vegas basin and set off 9 chemical blasts. Overall the data quality is high given that the deployment took place in an urban area where noise is tremendous 24/7.

Reports published

Progress Report submitted to the U. S. Geological Survey NEHRP Program

Data Availability

The SEGY data will be available at the IRIS DMC and will be held for 2 years before being released to the public.

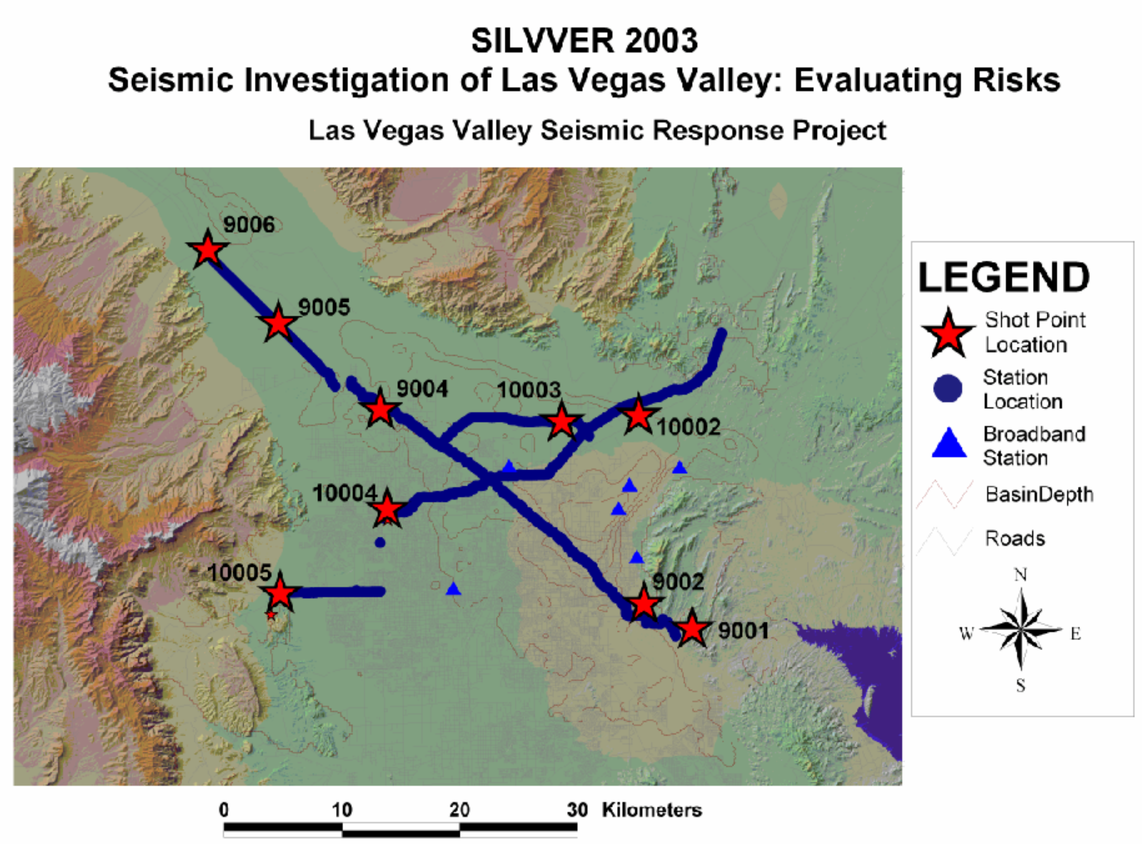

Figure 1. Basemap of the SILVVER '03 project. The dots are the station locations, the stars are the shot point locations, and the triangles are the location of the broadband stations. The light brown contours are the estimate basin depth based on the gravity inversion from Langenheim et al. (2001).

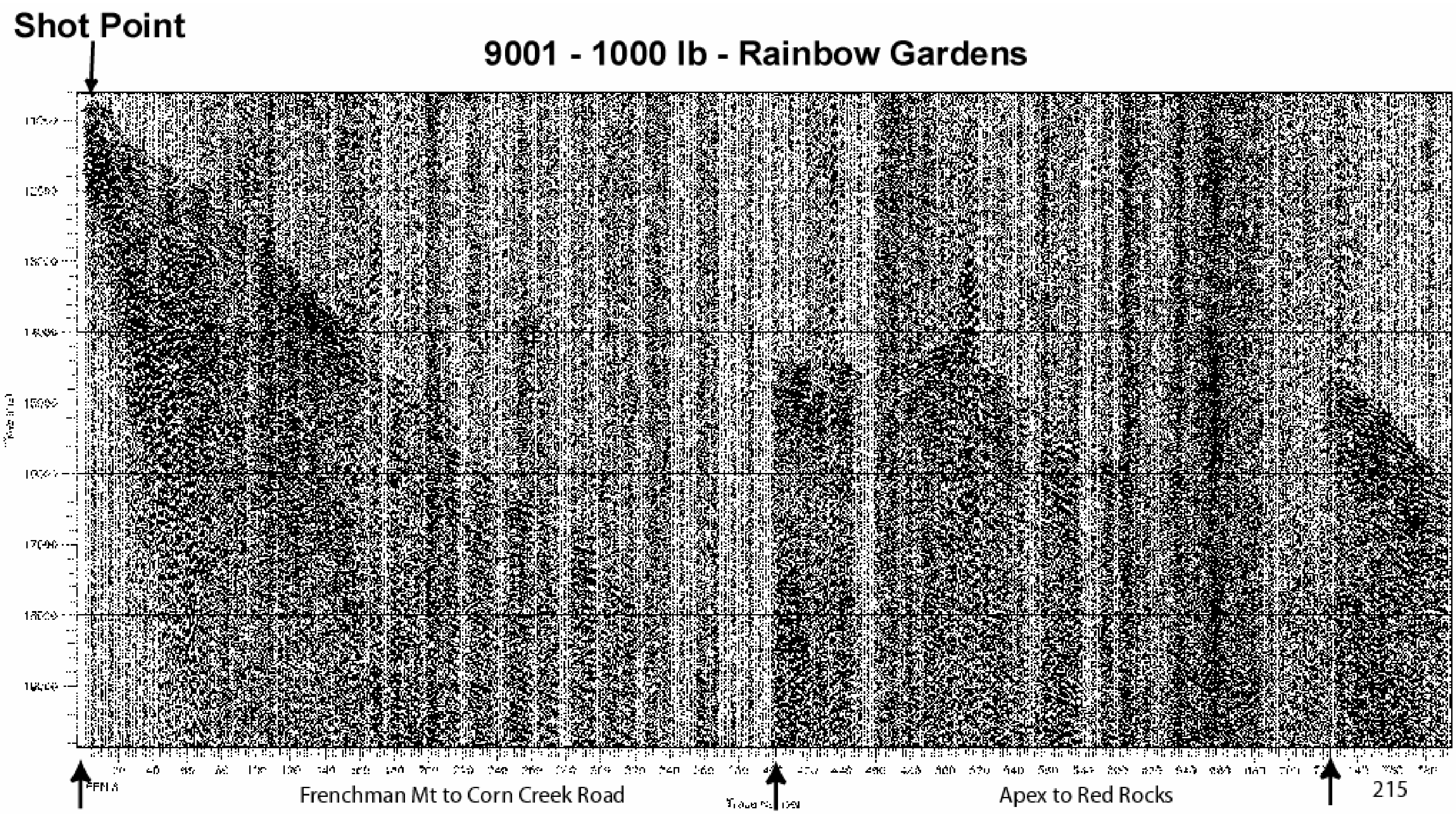

Figure 2. Shot record from the 9001 shot point. This is a raw section that contains all stations across all three profiles.